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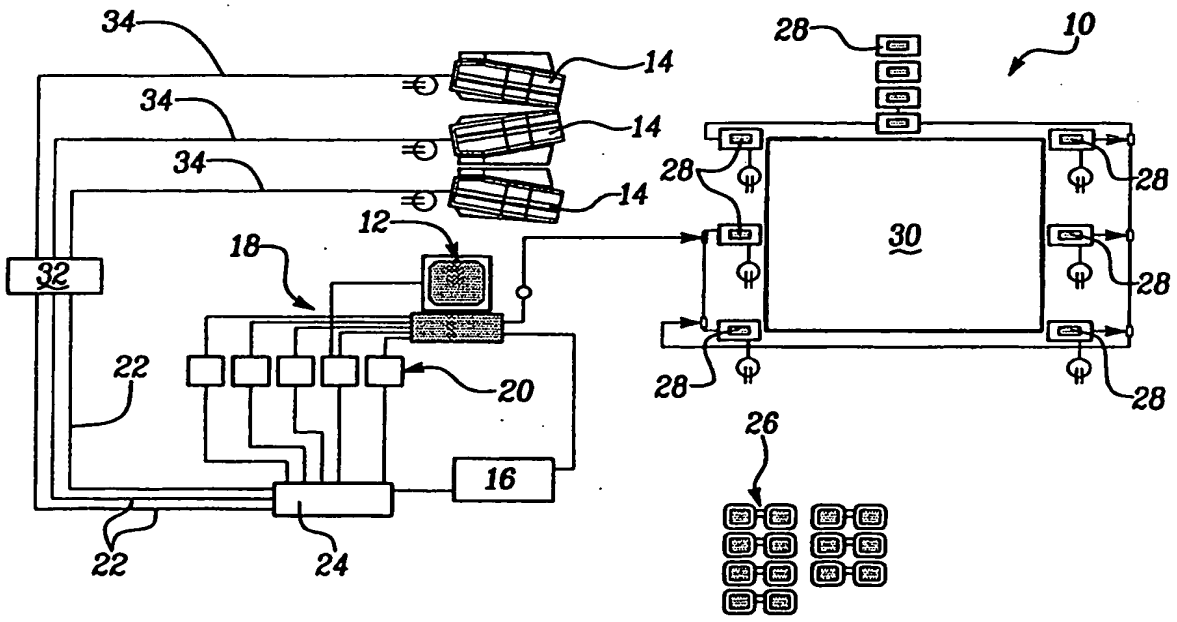

(57) Abstract

A projection display system with virtual reality capabilities. The system comprises a multi-pipe graphics engine (27) having a controller (16) cooperating therewith to produce a plurality of different video signals. The system also includes a plurality of projectors (14) which project video images corresponding to and upon receipt of the video signals from the graphics engine and the controller. A screen (30) is positioned relative to the projectors to have the video images projected thereon. The screen, having a top, sides and a bottom, is constructed without supports along the bottom which would interfere with the projection of the images from the projectors completely down to the lowermost bottom periphery of the screen.

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MULTIPLE PROJECTORS ON THE SAME SCREEN GRAPHIC DISPLAY SYSTEM

CROSS REFERENCE TO RELATED APPLICATION

This application claims the benefit of earlier filed provisional application serial number 60/053,271, filed July 21, 1997.

BACKGROUND

1. Field of the Invention

The present invention generally relates to projection display systems. More particularly, the invention relates to a rear projection, immersive visualization system for virtual reality (VR) applications and other large scale data viewing uses.

2. Discussion of Prior Art

Technological advancements and business requirements have made the use of video display systems a standard practice for group meetings and group project visualization reviews. In some situations, such as when the object of the project is large (e.g. an automobile), a larger and wider viewing screen is necessary to achieve the desired effect of the presentation. While prior systems have allowed a group of people to view a large screen, these systems have historically been front projection systems with resolution limited to a single graphics pipe. Such systems have numerous limitations when intended to present an immersive environment.

The projectors of a front projection system are typically mounted within the seating area of the viewing group. Placement of the projectors is limited to mounting them above the members of the group, typically on the ceiling, and projecting the images downward and forward onto a screen. When the screen is large and intended to provide an immersive experience, the screen has been curved (with the viewing group located on the concave side of the curved screen). As the screen becomes larger, the projector or projectors are inevitably located a distance away from the screen which may be greater than the distance of some of the individuals in the viewing group. As a result, if an individual approaches the screen, as is encouraged when developing a product and working in an immersive environment, a shadow caused by that individual is cast upon the screen. While the shadow may be minimized by increasing the angle at which the projector(s) is positioned, it cannot be completely eliminated. As a consequence of the shadow, the immersive "deception" perceived by the other audience members is lost, as well as being lost by the member who approached the screen. Additionally, as the angle is increased, uneven illumination across the height of the screen results.

As suggested above, a goal of visualization systems is to increase the immersiveness (the perception by the viewer that the image is real) of the system. One way in doing this has been to widen the screen providing for a greater degree of peripheral vision, as well as for the viewing of larger, life size images by increasing the resolution of the system. Unfortunately, prior systems have not taken into consideration other aspects of how people experience the real world and how those aspects affect the immersiveness of their systems. Prior systems have accordingly focused on the actual image itself and not on how an individual experiences the image.

In view of the limitations of the prior art as described above, it can be seen that there exists the need for an improved display system and an object of the present invention is to provide a display system which overcomes those drawbacks and limitations. Accordingly, it is a principal object of the present invention to provide a display system which has its design focused on how an individual experiences the projected image so as to provide a more immersive experience.

SUMMARY OF THE INVENTION

The projection display system of the present invention is a rear projection system in which two or more images are combined to form a composite image that is presented so as to be more naturally experienced by the viewer. The images are projected side by side onto a screen so that they partially overlap one another. The overlapped portions of the images correspond to one another and the light intensity in this overlap is manipulated or blended to create a seamless transition from one image to the other. The composite image is accordingly a larger or wide image with higher total resolution. The distance from the projectors to the screen can also be reduced since each projector produces only a portion of the composite image. Accordingly the front to back footprint of the system is reduced.

While the present discussion is presented in detail, it should be noted that the specific selection and location of the various components of the system will be dependent on the overall size of the system and intended images.

The system of the present invention includes a large screen of a rigid, low gain material which extends and rests directly on the floor of the viewing room. Located behind the screen are two or more projectors. As mentioned above, images are provided to the projector via a graphics engine which generates a number of video signals which correspond to the number of projectors. Prior to being received by the projectors, the video signals are manipulated so that their overlapping edges, once projected, are blended to form a seamless composite image on the screen. Infrared emitters may be positioned at various locations behind and around the screen and directed toward the members of the viewing group. The emitters, when used, operate with active stereoscopic glasses, worn by the viewers, to decode a multiplexed image and providing for stereoscopic viewing. The invention could also be utilized with other types of eyewear for achieving similar effects.

The specifics of the present invention will be more fully understood from the following detailed description when considered in conjunction with the attached figures.

While the above description constitutes the preferred embodiment of the present invention, it will be appreciated that the invention is susceptible to modification, variation and change without departing from the proper scope and fair meaning of this description of the invention and the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic illustration of a display system embodying the principles of the present invention;

FIGS. 2a and 2b are side elevational views of the screen and projectors utilized in the present invention with FIG. 2b showing one projector mounted in an inverted position;

FIG. 3 is a top elevational view of the projectors and screen utilized in the present invention; and

FIG. 4 is a front view of the screen and projector seen in FIG. 3 with the projections being illustrated through the screen itself.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawing, a projection display system according to the principles of the present invention is seen in FIG. 1 and generally designated at 10. The present system 10 includes a multi-pipe graphics engine 27, such as one of the Onyx line of graphics engines manufactured by Silicon Graphics, Inc., Mountain View, California. Depending on the number of projectors 14 being utilized, the graphics engine 12 in cooperation with a computer controller 16, generates the appropriate number of video signals (pipes) as well as any additionally required signals, such as audio signals. These signals are provided over lines 18 to a series of computer interfaces 20 that copy, amplify and buffer the signals for transmission across longer runs of wire 22. Optionally, a multiple input matrix switcher 24 which allows additional signal sources and formats to be coupled to the system 10, can be employed and provided. One signal produced by the controller 16 synchronizes eyewear 26 to a projected stereoscopic image, when such eyewear 24 is used. Synchronization in the present invention occurs via a series of long range emitters 28 located generally behind and about the perimeter of a screen 30. The emitters 28 emit signals, such as infrared signals, which are in turn received by the active stereoscopic eyewear 26 worn by the viewing group members (not shown) positioned in front of the screen 30. An example of appropriate stereoscopic eyewear 26 includes those manufactured by Stereographics, Inc., San Rafael, CA. During use, the signals received by the eyewear 26 cause shuttering to occur in the stereoscopic eyewear 26 enabling the viewers to see the stereoscopic image being projected onto the screen 30.

From the computer interfaces 20 and matrix switcher 24, if provided, the appropriate number of video signals are fed over RGB video cables 22 to an edge blender 32, such as a PanoMaker 3 series by Panoram Technologies, Inc., Burbank, CA, or one of the edge blending devices produced by SEOS, Ltd. (England). Edge blending technology is well known in the field and is described in U.S. Patent Nos. 4,974,073 and 5,136,390, which are herein incorporated by reference. Generally, the edge blender 32 establishes a consistent or uniform image brightness across the overlap area of the projected video images resulting in a seamless display of the composite image on the screen 30, even though multiple projectors 14 are being utilized.

From the edge blender 32, the enhanced video image signals are transmitted via RGB video cables 34 to the appropriate stereoscopic projectors 14, which in turn projects the images onto the rear surface or projection side of the screen. The projectors utilized in the present invention are commercially available models, such as Electrohome Marquee 9500P43 Stereoscopic Projectors manufactured by Electrohome, Kitchener, Ontario, Canada. The projectors 14 are supported on frames 42 which raise them to one half the height of the screen 30. The images projected by the projectors 14 overlap one another as seen in FIGS. 2-4, thus the need for the edge blender mentioned above. Additionally, adjacent projectors 14 may be rotated about an axis (corresponding to the direction of projection) to provide for better color dispersion across the screen 30. In the figures, the middle projector 14 has been inverted or rotated 180° relative to the remaining projectors 14.

The screen 30 employed with the present invention is large in size, preferably about 20 ft. wide and

8 ft. high, and provided as a single sheet. Multiple sheets can be used to form the screen. However, use of multiple sheets may result in some distortions of the projected composite image at the abutment of the adjacent edges of the screens. The screen 30 is made of a rigid acrylic or plexiglass material having at least a low gain and more preferably a unity gain. Once such material for the screen is manufactured by Draper Shade and Screen, Inc., Spiceland, Indiana and sold under the Cineplex tradename. Preferred coatings and tint with the aforesaid are the Cine 10 ultra wide angle optical coating and a white optical tint. A material according to the above specifications is preferred since it increases the dispersion of light through the screen allowing for better oblique or off angle viewing of the images being presented on the screen. Preferably the screen material exhibits a half gain angle of at least 70°. More preferably is a half gain angle of 90° and still more preferably is a half gain angle of 110°. By increasing the half gain angle color shift and mis-matching is reduced.

The screen 30 is positioned so that its lower edge 36 rests directly on the floor 38 of the viewing room. A support frame 40 is located on both sides and the top periphery of the screen 30. The frame 40, which may be constructed of extruded aluminum, is preferably secured to both ceiling and the floor of the viewing room, increasing the stability and rigidity of the screen 30. Notably there is no frame across the bottom of the screen 30 so that there are no supports to interfere with the video images being projected completely down to the lowermost edge of the bottom of the screen 30.

Since no frame 40 is located along the lower periphery of the screen 30, the screen 30 rests directly on the floor 38 of the viewing room and the projected image can be generated completely down to the bottom of the screen 30 so that the image appears to actually be resting on the floor 38 of the viewing room or to be a natural extension of the viewing room. This enhances the immersive nature of the system 10, as perceived by the viewing group.

With a screen 30 of the above mentioned size, it is readily apparent that the full size imaging of various products, such as automobiles, can be accommodated as well as true-to-scale visualization of the environment in which the object is presented. For example, when viewing the automobile, with the screen 30 of the present invention resting directly on the floor 38 of the viewing room, the projected image of the automobile can be designed so that the image of the automobile is one where the automobile is in an auto dealer's show room and the floor of the show room is an extension of the floor of the viewing room. In fact, the projected image may even reflect off of the floor 38 of the viewing room, if that floor 38 is sufficiently polished.

A major problem in VR situations having "open space" viewing is that when the viewing screen is located up off of the floor of the viewing room, the "open space" effect is lost. In other words the screen is located on a "stage" and the viewers themselves are actually standing somewhat below the level of the "stage". The feeling is instead one of looking out a window. The natural, everyday viewing of objects rarely occurs where the object is elevated relative to the viewer. Normally, a viewer perceives the floor or ground relative to the viewed object. By allowing the image and its projected surrounding to be contiguous with the ground felt by the viewer and actually seen by the viewer, the immersiveness of the projected image is greatly enhanced. Also, by presenting a viewed image up on a stage area, in a VR application where the room is dark, the stage represents a tripping hazard to the viewing group members as they approach the screen. Approaching the screen is encouraged in VR applications.

Furthermore, by placing the projectors behind the screen as in the present invention, there is no concern with shadows being cast on the screen if a viewer moves toward the projection. In the present invention, a viewer may stand directly in front of the screen and even touch the screen without affecting the displayed image or the immersiveness of the system with respect to other viewers. In fact, by having an individual approach the screen, the immersiveness of the other views is enhanced by the illusion of the first person actually being in the VR space.

Additional elements can be incorporated into the system if desired. For example, the system 10 could include two standard or modified projectors 14 per image in order to provide greater overall clarity; the projectors 14 may be inverted, completely or rotated 90° to increase color uniformity; the system 10 can include tracking technology to monitor one or more viewer's position and manipulate the image accordingly; the screen 30 could be constructed of multiple panels, as mentioned above, with appropriate measures being taken to eliminate distortion caused by abutting/overlapping edges of the panels; and the screen material may be augmented to include "electrotouch" draw capabilities directly on the screen surface.

While the above description constitutes the preferred embodiment of the present invention, it will be appreciated that the invention is susceptible to modification, variation and change without departing from the proper scope and fair meaning of the accompanying claims.

CLAIMS

I claim:

1. A projection display system with virtual reality capabilities, said system comprising:

a multi-pipe graphics engine;

a controller cooperating with said graphics engine to produce a plurality of different video signals;

a plurality of projectors connected to receive said video signals, said projectors to project video images corresponding to said video signals from said graphics engine and said controller; and

a screen having a projection side and a viewing side on opposite sides thereof, said screen positioned relative to said projectors to have said video images projected on said projection side, said screen also having a top, sides and a bottom, said bottom of said screen being constructed without supports interfering with the projection of said images from said projectors completely down to said bottom of said screen.

2. A projection display system according to Claim 1 wherein said screen is constructed without supports interfering with the projection of said images from said projectors completely down to a lowermost edge of said bottom of said screen.

3. A projection display system according to Claim 1 further comprising a frame supporting said screen, said frame extending along portions of said screen other than said bottom of said frame.

4. A projection display system according to Claim 1 further comprising a frame supporting said screen, said frame extending along said top and sides of said screen.

5. A projection display system according to Claim 4 wherein said frame is a rail.

6. A projection display system according to Claim 4 wherein said frame is an extruded aluminum rail.

7. A projection display system according to Claim 1 wherein said screen is formed of a single sheet of material.

8. A projection display system according to Claim 1 wherein said screen is formed of one of the following materials: plexiglass or acrylic.

9. A projection display system according to Claim 1 wherein said screen includes a wide angle coating.

10. A projection display system according to Claim 1 wherein said screen includes a white optical tint.

11. A projection display system according to Claim 1 wherein said screen exhibits low gain.

12. A projection display system according to Claim 1 wherein said screen exhibits unity gain.

13. A projection display system according to Claim 1 wherein said screen exhibits a half gain angle of at least 70°.

14. A projection display system according to Claim 1 wherein said screen exhibits a half gain angle of about 110°.

15. A projection display system according to Claim 1 wherein said screen has a horizontal length greater than its height.

16. A projection display system according to Claim 1 wherein said different video images have overlapping image portions.

17. A projection display system according to Claim 16 further comprising an edge blender, said edge blender receiving said video signals and manipulating said signals in said overlapping image portions to produce substantially equal brightness and resolution over substantially all of a composite video image formed of said different video images projected onto said screen.

18. A projection display system according to Claim 1 wherein at least one projector is rotated relative to the other projector about a axis corresponding to the direction of projection.

19. A projection display system according to Claim 1 further comprising emitters positioned about said screen and eyewear responsive to signals produced by said emitters, said signals produced by said emitters being controlled by said controller.

20. A projection display system according to Claim 1 further comprising a room in which said screen is located, said room including a floor and said bottom of said screen being directly supported on a support surface corresponding to said floor.

21. A projection display screen with virtual reality capabilities, said screen comprising:

a single sheet of material having a viewing side and a projection side, said viewing side and said projection side being on opposite sides of said sheet and allowing an image to be projected on to said projection side and viewed on said viewing side, said sheet further having a top, sides and a bottom, said bottom of said screen constructed without supports interfering with the projection of images onto said projection side and completely down to said bottom of said screen.

22. A projection display screen according to Claim 21 wherein said screen is constructed without

supports obstructing projection of said images from projectors completely down to a lowermost edge of said bottom of said screen.

23. A projection display screen according to Claim 21 further comprising a frame supporting a screen, said frame extending along portions of said screen other than said bottom.

24. A projection display screen according to Claim 21 further comprising a frame supporting said screen, said frame extending along said top and sides of said screen.

25. A projection display screen according to Claim 21 wherein said screen is formed of a single sheet of material.

26. A projection display screen according to Claim 21 wherein said screen is formed of one of the following group of materials: plexiglass or rigid acrylic.

27. A projection display screen according to Claim 21 wherein said screen includes a wide angle coating.

28. A projection display screen according to Claim 21 wherein said screen includes a white optical tint.

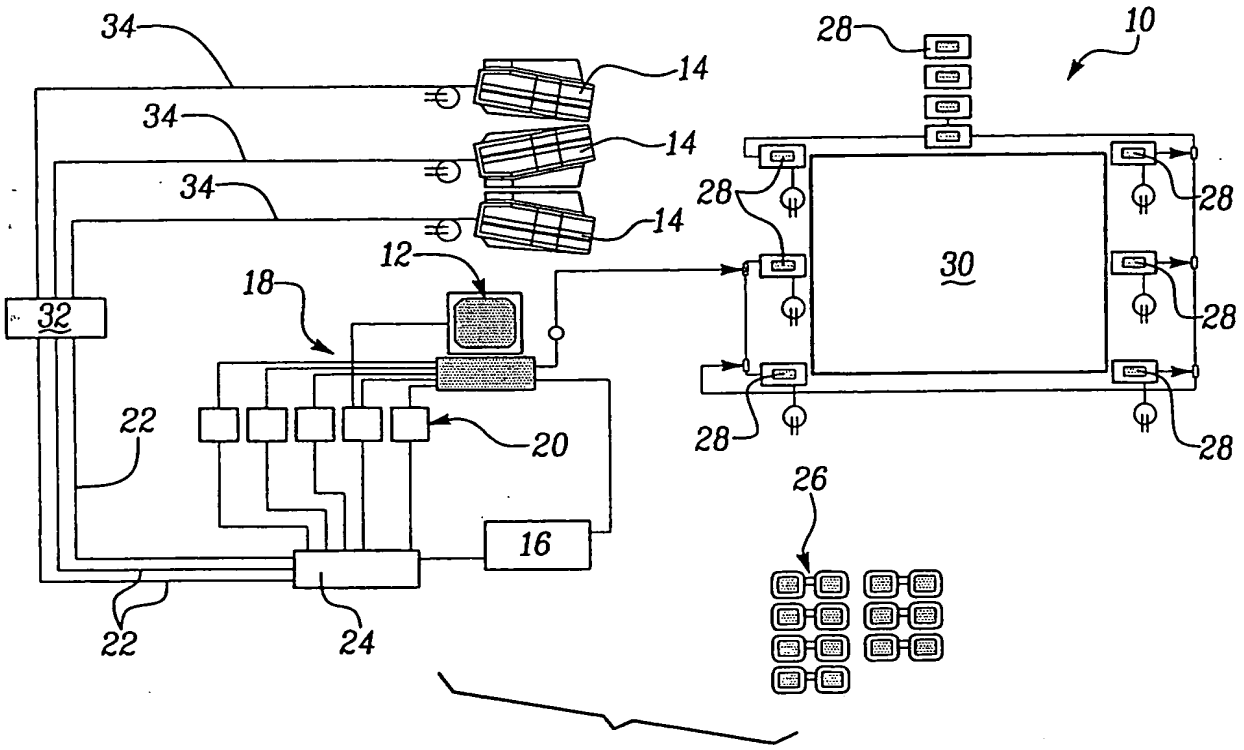
29. A projection display screen according to Claim 21 wherein said screen exhibits low gain.

30. A projection display screen according to Claim 21 wherein said screen exhibits unity gain.

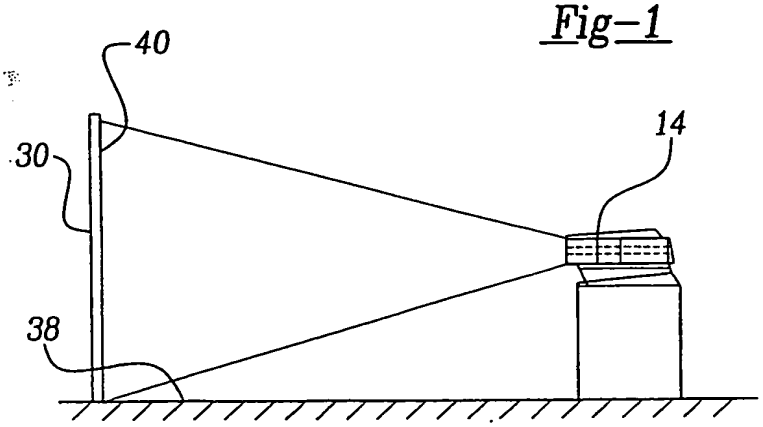
31. A projection display screen according to Claim 21 wherein said screen has a half gain angle of at least 70°.

32. A projection display screen according to Claim 21 wherein said screen has a half gain angle of about 110°.

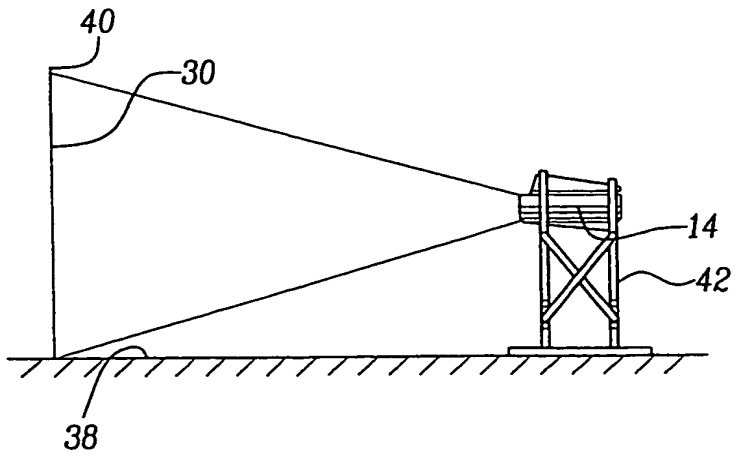
33. A projection display screen according to Claim 21 wherein said screen has a horizontal length and a height, said length being greater than said height.



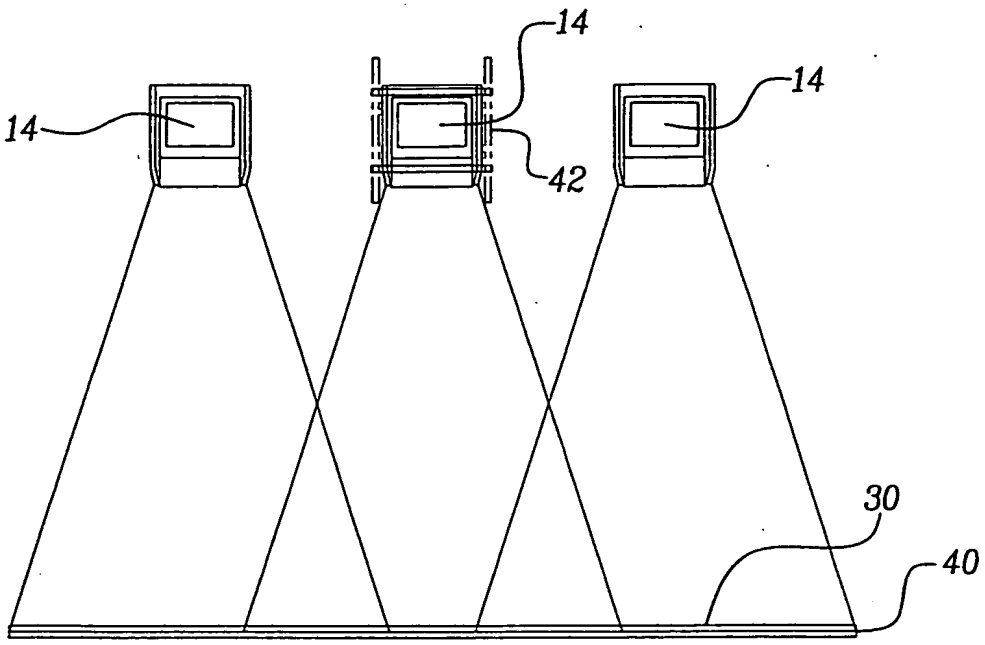
Fig–1



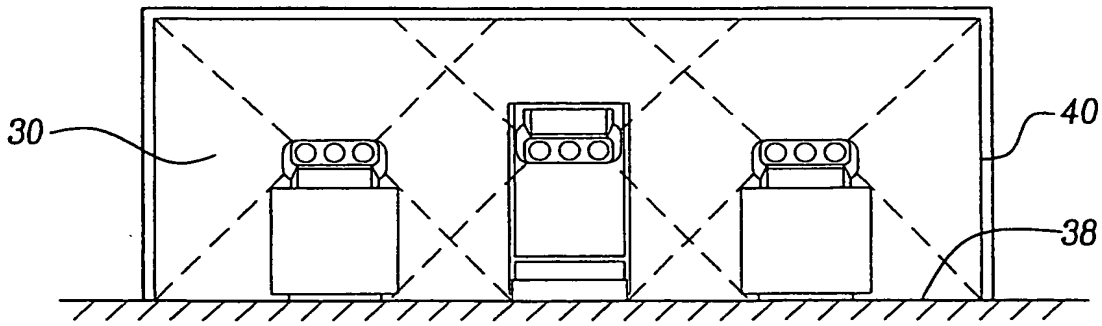
Fig–2A



Fig–2B



Fig–3



Fig–4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US98/15037

A. CLASSIFICATION OF SUBJECT MATTER
IPC(6) :HO4N 5/74, 7/18
US CL :348/744, 121, 750
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 348/744, 121, 750, 121-124, 751, 756

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

APS
search terms: projectors, screen, graphics, overlap?, superimpos?

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5,242,306 A (FISHER) 07 SEP. 1993, COL. 2, LINE 25, TO COL. 5, LINE 36.	1-33
X	US 4,974,073 A (INOVA) 27 NOV 1990, COL. 2, LINE 28, TO COL. 6, LINE 40.	1-33
X	US 5,746,599 A (LECHNER) 05 MAY 1998, COL. 5, LINE 30, TO COL. 12, LINE 3.	1-33
A	US 5,582,518 A (HENIQUE ET AL.) 10 DEC. 1996, THE WHOLE DOCUMENT.	1-33
A	US 4,740,779 A (CLEARY ET AL.) 26 APR. 1988, THE WHOLE DOCUMENT.	1-33

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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